Determinants, Persistence and Dynamics of Energy Poverty: An Empirical Assessment Using German Household Survey Data

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What is Energy Poverty?

- Experiencing an inadequate level of domestic energy services, but no uniform definition
- Primary indicators to capture different dimension of energy poverty by EU:
  - Arrears on utility bills
  - Low absolute energy expenditures
  - High share of energy expenditure on income
  - Inability to keep the house adequately warm
- Related to energy inefficient homes, high energy costs and low household income

Measuring Energy Poverty

Expenditure-based approach

It is based on monthly household expenditures on domestic energy services relative to household income, with a household considered energy poor if the share of income spent on energy is more than twice the national median

Consensual approach

It is based on self-reported inability to secure a certain level of domestic energy services

Motivation

- Just and fair energy transition
- Negative welfare effects
  - Reduction of mental and physical health
  - Reduction of childrens' educational attainment
- Requirement of targeted policy measures to tackle energy poverty

Literature Review

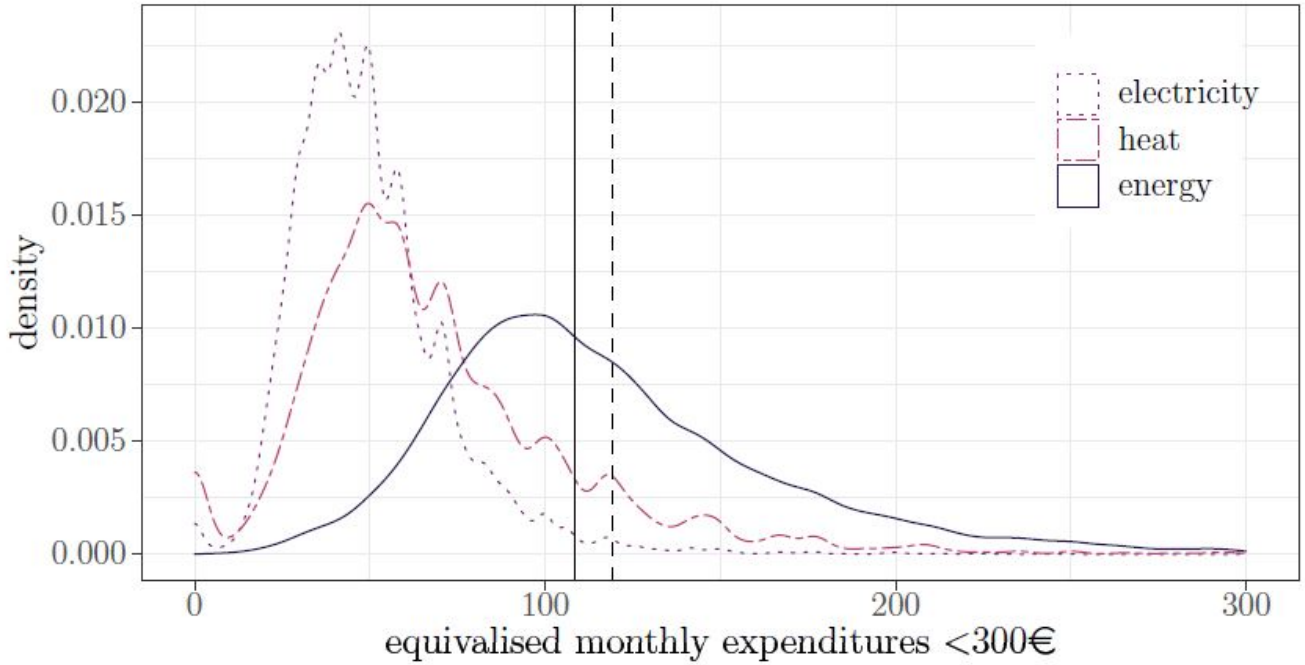
- Starting with Boardman (1991), there is a well-established literature body on the extent of energy poverty in the UK and Ireland
- Growing number of studies on the prevalence of energy poverty in other European countries
- Empirical findings on determinants of energy poverty are rather limited:
  - Healy & Clinch (2004) find that the long-term ill and lone-parent families are among the most energy vulnerable households in Ireland
  - Heindl & Schuessler (2019) find that income, energy expenditure, employment status and housing conditions determine energy poverty in Germany
- Few studies in dynamic context:
  - Phimister et al. (2015) find that there is a greater movement out of expendititure-based energy poverty relative to subjective energy poverty and income poverty in Spain
  - Chaton & Lacroix (2018) show that energy poverty in France is mostly a transitory state

Data

- German Socio-Economic Panel (GSOEP)
- Information on socio-economic, socio-demographic characteristics and housing conditions
- 3 waves (2016-2018)
- Balanced panel
- 9.032 households

Descriptives

Figure 1: (a) PDF of electricity, heating and energy expenditures (b) income profiles and average monthly expenditures on domestic energy services, pooled sample 2016-2018



Note: Dashed horizontal line represents the mean value of the distribution, while the solid horizontal line represents the median value.

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Average income (€)	766.28	1083.18	1306.20	1484.92	1688.54	1900.93	2135.88	2452.79	2927.97	4543.67
Electricity cost (€)	46.43	48.14	48.05	47.97	48.83	49.56	50.52	50.73	52.58	59.70
Heating cost (€)	58.59	61.58	64.47	65.25	67.22	69.51	69.07	68.88	74.61	87.57
Total energy cost (€)	105.02	109.72	112.51	113.22	116.05	119.07	119.59	119.62	127.19	147.27
Share of income spent on energy (%)	13.71	10.13	8.61	7.62	6.87	6.26	5.60	4.87	4.34	3.24
Energy Use Intensity (€/sqm)	1.44	1.31	1.20	1.15	1.15	1.13	1.04	1.01	1.02	1.03

Empirical Strategy

1. **Dynamic random effects probit model** → identifying driving factors of energy poverty dynamic panel data model
2. **Identification function & multinominal logit model** → differing between chronic and transient energy poverty

Dynamic Random Effects Probit

$$y_{it} = 1[y_{it}^* > 0] \tag{1}$$

$$y_{it}^* = \gamma y_{it-1} + x_{it}'\beta + u_i + \epsilon_{it}, \qquad i = 1, ..., N; t = 1, ..., T \tag{2}$$

- But: initial conditions problem
- Solution: specifying a distribution of heterogeneity conditional on the energy poverty status of a household at the beginning of our panel (Wooldridge, 2005, 2010):

$$u_i = \alpha_0 + \alpha_1 y_{i0} + \bar{x}_i'\alpha_2 + v_i, \qquad v_i \sim N(0, \sigma^2), \tag{3}$$

$$y_{it}^* = \gamma y_{it-1} + x_{it}'\beta + \alpha_0 + \alpha_1 y_{i0} + \bar{x}_i'\alpha_2 + v_i + \epsilon_{it}, \tag{4}$$

Identification Function & Multinominal Logit

- Identification Function

$$\psi_\tau(y_i; z) = \begin{cases} 2, & \text{if } d_i \geq \tau, \\ 1, & \text{if } 0 < d_i < \tau, \\ 0, & \text{if } d_i = 0. \end{cases} \tag{5}$$

where y_i is a energy poverty measure, z the energy poverty line, d_i the fraction of periods where $y_i < z$ and τ is an arbitrary duration line.

- Multinominal Logit

$$Pr(y_{ij} = \psi \mid x_i') = \frac{e^{x_i' \beta_\psi}}{1 + \sum_{k=1}^{2} e^{x_i' \beta_\psi}}, \qquad \psi = 0, 1, 2, \tag{6}$$

where never poor ($\psi = 0$) is the reference group.

Results

Table 1: Regression Results: Dynamic Random Effects Probit

	Expenditure-based		Consensual	
	(1)	(2)	(3)	(4)
Expenditure-based$_{t-1}$	0.373***	0.198***		
	(0.013)	(0.015)		
Expenditure-based$_{t=0}$		0.131***		
		(0.013)		
Consensual$_{t-1}$			0.210***	0.065***
			(0.023)	(0.016)
Consensual$_{t=0}$				0.071***
				(0.017)
Household type				
Couple without children	Ref.	Ref.	Ref.	Ref
Single parent	0.070***	0.072***	0.012***	0.010***
	(0.010)	(0.010)	(0.004)	(0.004)
One person household	0.067***	0.064***	0.005**	0.004**
	(0.007)	(0.007)	(0.002)	(0.002)
Couple with children	−0.020***	−0.018***	−0.001	−0.001
	(0.005)	(0.005)	(0.002)	(0.002)
Other	0.011	0.012	−0.001	−0.001
	(0.015)	(0.015)	(0.005)	(0.005)
Migration background	0.031***	0.028***	0.001	0.001
	(0.008)	(0.008)	(0.002)	(0.002)
Region	0.013***	0.015***	0.003	0.004*
	(0.005)	(0.005)	(0.002)	(0.002)
Education				
No degree	0.020**	0.018**	−0.001	−0.002
	(0.008)	(0.008)	(0.002)	(0.002)
Lower secondary degree	0.016**	0.013*	−0.003*	−0.003*
	(0.007)	(0.007)	(0.002)	(0.002)
Upper secondary degree	Ref.	Ref.	Ref.	Ref
Tertiary degree	−0.032***	−0.030***	−0.001	−0.001
	(0.004)	(0.004)	(0.002)	(0.002)
Labour Force Status				
(Self-)Employed	Ref.	Ref.	Ref.	Ref
Non-working	0.101***	0.095***	0.011***	0.010***
	(0.011)	(0.010)	(0.003)	(0.003)
Retired	0.045***	0.043***	−0.002	−0.002
	(0.005)	(0.005)	(0.002)	(0.002)
Owner	−0.008	−0.007	−0.010***	−0.010***
	(0.005)	(0.005)	(0.002)	(0.002)
Thermal insulation	−0.023***	−0.021***	−0.006***	−0.006***
	(0.004)	(0.004)	(0.002)	(0.002)
Construction Year				
Built before 1949	Ref.	Ref.	Ref.	Ref
Built between 1949 and 1979	−0.009**	−0.007	0.001	0.001
	(0.004)	(0.004)	(0.002)	(0.002)
Built after 1979	−0.017***	−0.016***	−0.001	−0.001
	(0.004)	(0.004)	(0.002)	(0.002)
Housing Type				
Detached	Ref.	Ref.	Ref.	Ref
Semi-detached	−0.016***	−0.015***	−0.003	−0.003
	(0.005)	(0.005)	(0.002)	(0.002)
Apartment building	−0.035***	−0.033***	−0.002	−0.002
	(0.005)	(0.005)	(0.002)	(0.002)
Heating Type				
Gas	Ref.	Ref.	Ref.	Ref
Oil	0.020***	0.019***	0.006***	0.006***
	(0.005)	(0.005)	(0.002)	(0.002)
Electricity	0.048***	0.042***	0.011**	0.010**
	(0.012)	(0.011)	(0.005)	(0.005)
District heating	0.009	0.009	0.004*	0.004
	(0.006)	(0.006)	(0.002)	(0.002)
Other	0.006	0.006	0.002	0.002
	(0.008)	(0.008)	(0.003)	(0.003)
Environmental Behaviour				
Renewable energy	−0.015***	−0.014**	−0.003	−0.002
	(0.006)	(0.006)	(0.002)	(0.002)
Climate change concerns	−0.005	−0.004	0.001	0.001
	(0.004)	(0.004)	(0.001)	(0.001)
State fixed effects	Yes	Yes	Yes	Yes
Wave fixed effects	Yes	Yes	Yes	Yes
Number of obs.	18064	18064	18064	18064

Notes: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$, standard errors in parentheses.

Results

Table 2: Distribution of energy poverty duration states

	Expenditure-based		Consensual	
Energy poverty duration state	Share of households	Number of households	Share of households	Number of households
Never	0.809	7,309	0.958	8,649
Transient	0.144	1,305	0.038	345
Chronic	0.046	418	0.004	38
Total	1	9032	1	9032

(Preliminary) Conclusion

- Understanding determinants and dynamics of energy poverty is crucial for policy making
- Expenditure-based energy poverty higher than consensual energy poverty
- Facing energy poverty in one period significantly raises the probability of being energy poor in the subsequent period
- Energy poverty is mostly a transitory state

Caveats & Next Steps

Caveats

- Short panel limits sufficient analysis of energy poverty dynamics
- No consideration of the depth of energy poverty

Next Steps

- Adding recent wave of GSOEP (year 2019) to data set
- Including population share weights

Thank you for your attention!

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